

**DATA VALIDATION AND STATISTICAL
EVALUATION OF DECEMBER 2016
GROUNDWATER QUALITY**

CITY OF HELENA LANDFILL

Prepared For:

**CITY OF HELENA
HELENA, MONTANA**



Hydrometrics, Inc.
consulting scientists and engineers

MARCH 2017

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March 9, 2017

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MAR 13 2017
Dept. of Enviro. Quality
Waste & Underground
Tank Management Bureau

Mr. John Collins
Environmental Science Specialist
Solid Waste Regulatory Program
Montana Department of Environmental Quality
P.O. Box 200901
Helena, MT 59620-0901

RE: Statistical Evaluation of December 2016 Groundwater Quality Data at City of Helena
Landfill, License #SW-0090

Dear John,

On behalf of the City of Helena, Hydrometrics validated and statistically evaluated groundwater quality data for samples collected at the City's municipal landfill in December 2016. After receiving approval from Pete Anderson of the City of Helena, I am forwarding a copy of the report "Data Validation and Statistical Evaluation of December 2016 Groundwater Quality Data City of Helena Landfill" for your review.

If you have any questions concerning this report, please don't hesitate to call.

Sincerely,

Jodi Bingham, P.E.
Environmental Engineer/Chemist

Enclosure

c: Randall Camp, City of Helena, without Enclosure
Pete Anderson, City of Helena, without Enclosure
Mike Wignot, Hydrometrics, without Enclosure

**DATA VALIDATION AND STATISTICAL
EVALUATION OF DECEMBER 2016
GROUNDWATER QUALITY DATA**

CITY OF HELENA LANDFILL

Prepared for:

Mr. Randall Camp
City of Helena
City/County Building
316 North Park Avenue
Helena, MT 59623

RECEIVED

MAR 13 2017

Dept. of Environ. Quality
Waste & Underground
Tank Management Bureau

Prepared by:

Hydrometrics, Inc.
3020 Bozeman Avenue
Helena, MT 59601

March 2017

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**DATA VALIDATION AND STATISTICAL
EVALUATION OF DECEMBER 2016
GROUNDWATER QUALITY DATA
CITY OF HELENA LANDFILL**

1. REPORT OBJECTIVES

This report is prepared on behalf of the City of Helena Landfill to fulfill the groundwater data evaluation requirements provided in Administrative Rules, Montana (ARM) Title 17, Chapter 50. This report provides analytical results for groundwater samples collected at monitoring wells during the December 2016 monitoring event, summarizes the data validation results and statistically evaluates the data. The samples were collected and analyzed in accordance with the Montana Department of Environmental Quality (MDEQ) approved sampling and analysis plan (Hydrometrics, 2008).

ARM 17.50.1305(8) and ARM 17.50.1305(9) stipulate the types of statistical data evaluations to be performed on groundwater quality monitoring data from regulated landfills. Federal guidance on conducting statistical evaluations of groundwater data is also available (EPA, 1989; EPA, 1992). These regulations and guidance documents allow the use of a wide range of statistical procedures including: parametric analysis of variance, non-parametric analysis of variance, tolerance or prediction interval testing, trend tests or other statistical tests meeting the statistical testing objectives of the rules.

Statistical evaluations have been performed for this site semiannually since 1993 and the following conclusions have been reached based on the results of those evaluations:

- Chlorinated hydrocarbons occur downgradient of the landfill;
- Tetrachloroethene (PCE) is the chlorinated organic compound of greatest concern due to Maximum Contaminant Level (MCL) exceedances;

- These findings are further evaluated in this December 2016 statistical report through an assessment of current concentrations (Table 4-1), a comparison of summary statistics (Tables 4-2 and 4-3), an inter-well prediction analysis (Table 4-4) and an examination of temporal trends (Table 4-5 and Figures 4-1 and 4-2).

2. SITE DESCRIPTION

2.1 PHYSICAL FEATURES

A site location map is provided in Figure 2-1. The landfill is surrounded for several miles in all directions by residential, commercial and industrial zoned property. There are several businesses upgradient of the landfill, which have the potential to affect groundwater quality in the area.

A site plan is shown on Figure 2-2. The landfill is divided into three sections. The southern part of the landfill (Phase I and Phase II sections) is unlined and was in operation until the early 1980s. The northern part of the landfill (Phase III) is also unlined, and was in operation until November 1993. The Phase III landfill was originally capped with an 18-inch clay cover to minimize surface water percolation through the landfill and subsequent migration of chemicals into groundwater. In 2010, the entire landfill area was resurfaced and landscaped as part of the Centennial Park expansion and renovation project. New backfill material was brought in to bring the entire area to project grades and the cap depth now varies between two feet and more than 8 feet in some areas.

2.2 WELL LOCATIONS

Fourteen monitoring wells located around the landfill are included in the groundwater monitoring program and are characterized as follows:

- Background wells: HL-06-1, HL-94-1R, HL-94-2R, MPC-5;
- Downgradient wells: HL-10-1 (replaced HL-90-1), HL-90-2, HL-90-3, MPC-1, MPC-2, EPA-1, HL-99-1, HL-99-2, HL-99-3; and
- Cross-gradient well: HL-94-3.

As discussed in Section 3 and in accordance with the approved sampling and analysis plan (Hydrometrics, 2008), eight of these wells were included in the December 2016 sampling event. The locations of these wells are shown in Figure 2-2.



CITY OF HELENA LANDFILL
 DATA VALIDATION & STATISTICAL
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 GROUNDWATER QUALITY DATA

VICINITY MAP

FIGURE

2-1



SITE CODE DTWL MPE SWL

Dec-16

HL-06-1	17.72	3993.62	3975.90
EPA-1	46.56	3981.08	3934.52
EPA-2	dry	3981.286	
EPA-4	28.33	3973.83	3945.50
HL-10-1	55.56	3943.01	3887.45
HL-90-1	55.04	3942.48	3887.44
HL-90-2	47.61	3950.96	3903.35
HL-90-3	58.35	3958.29	3899.94
HL-94-1R	57.68	3994.04	3936.36
HL-94-2R	32.74	3967.64	3934.90
HL-94-3	35.97	3967.38	3931.41
HL-99-1	55.81	3943.15	3887.34
HL-99-2	56.76	3945.75	3888.99
HL-99-3	51.57	3948.05	3896.48
INF. GALLE	5.88	3918.89	3913.01
I-1	59.38	3899.59	3840.21
MPC-1	23.09	3946.08	3922.99
MPC-2	17.38	3936.09	3918.71
MPC-5	55.04	3990.14	3935.10



SCALE

0 (In Feet) 800

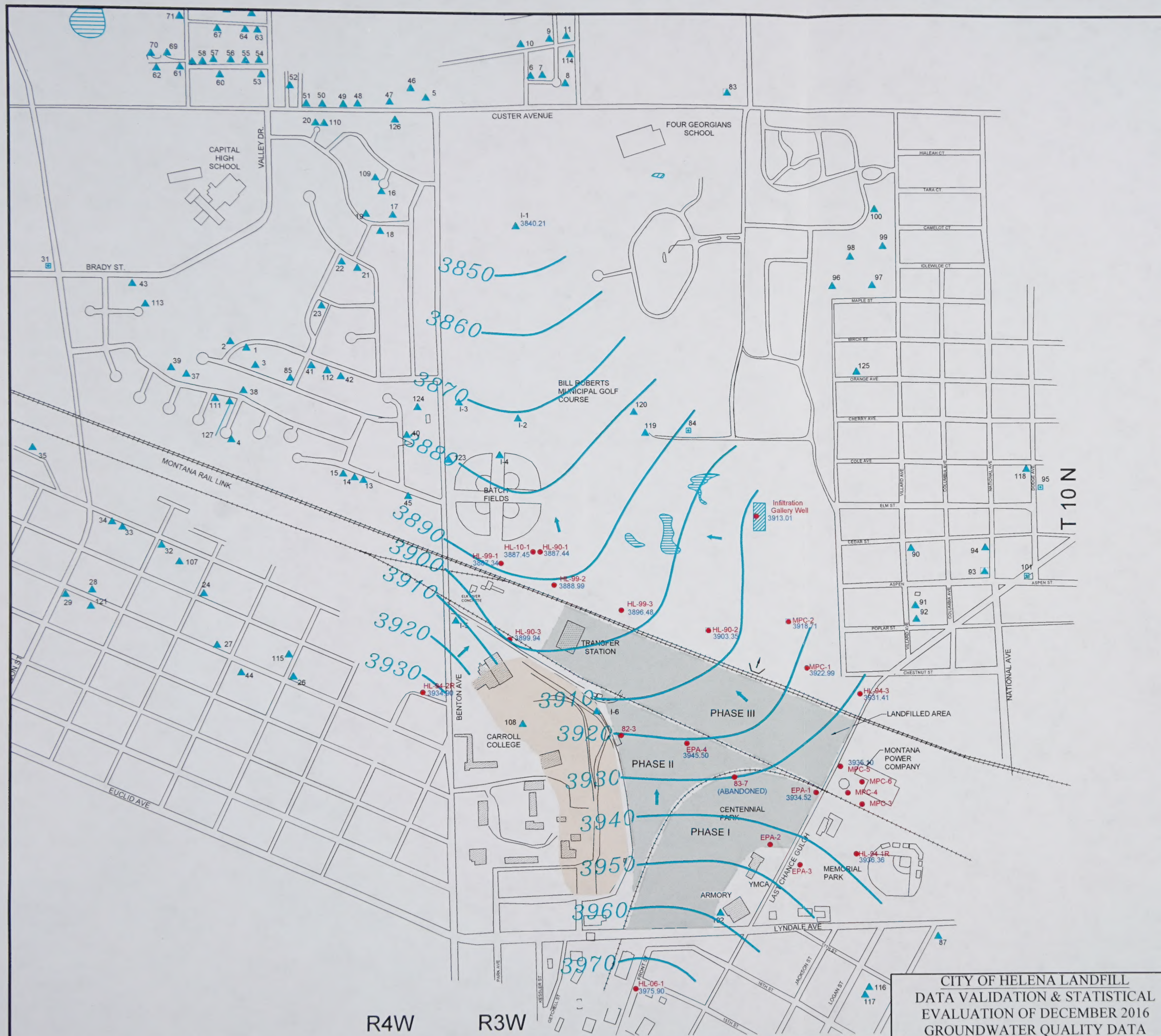
LEGEND

- 1 ■ PIEZOMETER
- 3-6 ● MONITORING WELL
- 6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

STUDY AREA AND DECEMBER 2016
POTENTIOMETRIC SURFACE

FIGURE

2-2



SITE CODE DTWL MPE SWL

Dec-16

HL-06-1	17.72	3993.62	3975.90
EPA-1	46.56	3981.08	3934.52
EPA-2	dry	3981.286	
EPA-4	28.33	3973.83	3945.50
HL-10-1	55.56	3943.01	3887.45
HL-90-1	55.04	3942.48	3887.44
HL-90-2	47.61	3950.96	3903.35
HL-90-3	58.35	3958.29	3899.94
HL-94-1R	57.68	3994.04	3936.36
HL-94-2R	32.74	3967.64	3934.90
HL-94-3	35.97	3967.38	3931.41
HL-99-1	55.81	3943.15	3887.34
HL-99-2	56.76	3945.75	3888.99
HL-99-3	51.57	3948.05	3896.48
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I-1	59.38	3899.59	3840.21
MPC-1	23.09	3946.08	3922.99
MPC-2	17.38	3936.09	3918.71
MPC-5	55.04	3990.14	3935.10



SCALE
0 (In Feet) 800

LEGEND

- HL-1 ■ PIEZOMETER
- 83-6 ● MONITORING WELL
- I-6 ▲ IRRIGATION WELL
- 80 □ DOMESTIC WELL
- INFILTRATION GALLERY (GROUNDWATER COLLECTION SYSTEM)
- AREA OF SHALLOW LOW PERMEABILITY BEDROCK
- 3900 — POTENTIOMETRIC CONTOUR LINE
- INFERRED GROUNDWATER FLOW DIRECTION
- STORM WATER OUTFALL FOR LAST CHANCE GULCH

CITY OF HELENA LANDFILL
DATA VALIDATION & STATISTICAL
EVALUATION OF DECEMBER 2016
GROUNDWATER QUALITY DATA

STUDY AREA AND DECEMBER 2016
POTENTIOMETRIC SURFACE

FIGURE
2-2

2.3 GROUNDWATER FLOW DIRECTION AND VELOCITY

Figure 2-2 shows water level elevations observed in December 2016 and groundwater potentiometric surface contours. Groundwater flow direction is also shown on this figure. The general groundwater flow direction in the vicinity of the landfill is to the north-northwest. Table 2-1 shows the groundwater velocities calculated for each of the monitoring wells sampled during the December 2016 sampling event. Slope was determined from the potentiometric contours shown in Figure 2-2. The hydraulic conductivities were obtained from the groundwater flow model inputs included in the report "Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill" (Hydrometrics, 1999a). The porosity for each well was assumed to be 0.25. An average regional gradient of 0.0226 ft/ft was determined between monitoring well HL-06-1 and I-1. This yields an average regional velocity of 0.736 ft/day.

TABLE 2-1. GROUNDWATER VELOCITIES

Well	Hydraulic Conductivity (ft/day)	Slope (ft/ft)	Velocity (ft/day)
HL-06-1	0.03	0.0268	0.00322
HL-10-1	20	0.0110	0.882
HL-90-1	20	0.0111	0.884
HL-94-1R	2.8	0.0196	0.219
HL-99-1	10	0.0293	1.17
HL-99-2	20	0.0222	1.78
HL-99-3	20	0.0219	1.75
MPC-5	2.8	0.0204	0.229

3. SUMMARY OF DECEMBER 2016 DATA VALIDATION REPORT

Eight monitoring wells around the landfill and two domestic wells were included in the December 2016 sampling event. Static water levels (SWL) were obtained from eight additional monitoring wells, one irrigation well, and the infiltration gallery. The December 2016 monitoring sites for the City of Helena Landfill include the following:

- Monitoring wells EPA-1 (SWL only), EPA-2 (SWL only), HL-06-1, HL-10-1, HL-90-1, HL-90-2 (SWL only), HL-90-3 (SWL only), HL-94-1R, HL-94-2R (SWL only), HL-94-3 (SWL only), HL-99-1, HL-99-2, HL-99-3, MPC-1 (SWL only), MPC-2 (SWL only), MPC-5;
- Irrigation well I-1 (SWL only);
- Domestic wells 5, 16; and
- The infiltration gallery (SWL only).

The December analytical parameters included metals, volatile organics, semi-volatile organics, halogenated organics, and major anions for all the monitoring wells and volatile organics, semi-volatile organics, and halogenated organics for all domestic wells as specified in the approved sampling and analysis plan (Hydrometrics, 2008).

The water samples collected for the City of Helena Landfill in December 2016 have been validated by the Hydrometrics' Data Validation Department in accordance with the project work plan, "Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities" (Hydrometrics, 2008). Lab and field quality control procedures were appropriate; quality control (QC) samples included a field duplicate, a D.I. blank, a trip blanks, a rinsate blank and standard internal laboratory QC samples. All field duplicate pair relative percent differences were within the required control limits. The sample for well MPC-5 was analyzed twice for total xylenes, o-xylenes, and m+p xylenes due to dilution issues. The second analysis which confirmed the previous results was conducted past the recommended holding time resulting in these values being flagged. The entire data validation report is included as Appendix A of this report. Overall, the City of

Helena Landfill data for December 2016 were deemed acceptable for the purposes of the project as outlined in the work plan.

Four types of data evaluations were conducted using the December 2016 sample results for the monitoring wells around the landfill. The data were evaluated separately in Section 5. The four types of data evaluations conducted were:

1. Comparison of applicable water quality criteria and applicable detection limits with the December 2016 sample results to determine if any of the monitoring wells for the December 2016 sampling event exceeded the detection limit for any of the monitored constituents.
2. Trend analysis of the data for the December 2016 sampling event.
3. Trend analysis of the data for the December 2016 sampling event.
4. Trend analysis of the data for the December 2016 sampling event.

The first three analyses include all of the parameters for which results were reported above the detection limit in any of the monitoring wells for the December 2016 sampling event. The fourth analysis, a temporal concentration plot, was performed for PCE and MCHL, the only constituents that have repeatedly exceeded their regulatory limits in the monitoring wells. Data from all wells sampled during the December 2016 sampling event, which have historically shown PCE results above the detection limit and MCHL results above the MCL of 10 mg/L or with potentially increasing trends, were evaluated.

As noted in previous reports, new laboratory reporting limits (LOQs) for VAPs (based on EPA Method 8260) were implemented in 2013 for certain VOCs and SVOCs, compared with previous typical reporting limits for the Helena Landfill ground water samples. In every case, the updated reporting limits are significantly lower than the previous limits. These reporting limit changes will impact the additional analysis of these constituents since parameters which were previously reported as consistently below the detection limit may now be quantified at concentrations lower than the previous limit. For monitoring wells which reported results consistently below the detection limit prior to the June 2013 sampling event, the data was removed from the data set prior to statistical analysis.

4. STATISTICAL DATA EVALUATION AND COMPARISON

Four types of data evaluations were conducted using the December 2016 sample results for the monitoring wells around the landfill. The domestic wells are evaluated separately in Section 5. The four types of data evaluations conducted are:

1. Comparisons of applicable water quality criteria and upgradient (also called “background”) water quality with summary statistics of downgradient concentrations for December 2016 and all samples to date;
2. Inter-well prediction interval analysis;
3. Trend analysis; and
4. Temporal concentration plots.

The first three analyses include all those parameters for which results were reported above the detection limit in any of the monitoring wells for the December 2016 sampling event. The fourth evaluation, temporal concentration plots, was performed for PCE and nitrate; the only constituents that have recently exceeded their regulatory limits in downgradient wells. Data from all wells sampled during the December 2016 sampling event, which have historically shown PCE results above the detection limit and nitrate results above the MCL of 10 mg/L or with potentially increasing trends, were evaluated.

As noted in previous reports, new lower laboratory reporting limits (DEQ-7 RRV-based) were implemented in 2012 for certain dissolved metals and VOCs, compared with previous typical reporting limits for the Helena landfill groundwater samples. In many cases, the updated reporting limits are significantly lower than the historic limits. These reporting limit changes will impact the statistical analysis of these constituents since parameters which were previously reported as consistently below the detection limit may now be quantified at concentrations lower than the previous limit. For monitoring wells which contained metals results consistently below the detection limit prior to the June 2013 sampling event, this data was removed from the data set prior to statistical analysis.

4.1 DOWNGRAIDENT WATER QUALITY COMPARISONS WITH CRITERIA AND UPGRAIDENT WATER QUALITY

The following conclusions are derived from the December 2016 data and summary statistics in Tables 4-1, 4-2, and 4-3:

- (a) For the December 2016 sampling event (Tables 4-1 and 4-2), the following parameters were detected only in background (also called upgradient) wells: cadmium, selenium, 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, total xylenes, and chemical oxygen demand. Parameters detected in only downgradient wells include: lead, zinc, 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, tetrachloroethene (PCE), trichloroethene (TCE), and trichlorofluoromethane.
- (b) The parameters historically detected only in background wells (Table 4-3) are benzene, bromodichloromethane, and o-xylene. Parameters historically detected only in downgradient wells include: 1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, TCE, and trichlorofluoromethane.
- (c) Nitrate, iron, benzene, PCE and cyanide were reported at concentrations exceeding MCL criteria in the December 2016 sampling event (Tables 4-1 and 4-2). The MCLs for benzene and cyanide were both exceeded in a single upgradient well (MPC-5); the MCL for nitrate was exceeded in two downgradient wells (HL-99-1 and HL-10-1) and one upgradient well (MPC-5); the MCL for PCE was exceeded in three downgradient wells (HL-99-2, HL-99-3, and HL-10-1); the secondary MCL (based on aesthetic properties rather than human health standards) for iron was exceeded in a single upgradient well (MPC-5).
- (d) Historically in these wells, nitrate, arsenic, iron, lead, benzene, PCE, and cyanide have been reported at concentrations exceeding MCL criteria (Table 4-3). The MCLs for benzene and arsenic have been exceeded in only upgradient wells; nitrate, iron, and cyanide have exceeded their MCLs in both upgradient and downgradient wells; and the MCLs for lead and PCE have been exceeded in only downgradient wells.

TABLE 4-1. SUMMARY OF PARAMETER CONCENTRATIONS IN LANDFILL MONITORING WELLS
FOR THE DECEMBER 2016 MONITORING EVENT

Parameter	Downgradient Wells					Upgradient Wells			GWPS ⁽¹⁾
	HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1	HL-06-1	HL-94-1R	MPC-5	
pH (s.u.)	7.2	7.3	7.4	7.3	7.0	7.1	7.4	7.0	NA
Specific Conductance (µmhos/cm)	1280	1040	1000	1260	1310	1010	1300	2730	NA
Sulfate	160	130	140	130	160	67	120	9.1	NA
Chloride	69	43	48	100	67	36	59	25	NA
Nitrate+Nitrite as N	11.1	7.4	9.5	8.9	11.4	1.83	8.8	15.8	10
Arsenic (Dissolved)	0.001	0.002	0.001	0.001	< 0.001	0.002	0.002	0.003	0.010
Barium (Dissolved)	0.068	0.052	0.041	0.067	0.076	0.050	0.066	0.040	1.0
Cadmium (Dissolved)	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	< 0.00003	0.00006	0.005
Copper (Dissolved)	0.007	< 0.002	0.003	< 0.002	< 0.002	< 0.002	< 0.002	0.002	1.3
Iron (Dissolved)	< 0.02	0.14	0.02	< 0.02	0.02	< 0.02	< 0.02	0.76	0.3 ⁽²⁾
Lead (Dissolved)	0.0008	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	0.015
Mercury (Dissolved)	0.0000310	0.0000179	0.0000240	< 0.000005	0.000240	< 0.000005	< 0.000005	0.0000076	0.002
Nickel (Dissolved)	0.003	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.01	0.10
Selenium (Dissolved)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.007	0.005	0.05
Zinc (Dissolved)	0.013	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	2.0
1,1,1-Trichloroethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0021	< 0.0005	< 0.0005	0.2
1,1-Dichloroethane	0.00088	0.0038	0.0019	0.0015	0.0027	< 0.0005	< 0.0005	< 0.0005	NA
Benzene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.882	0.005
Bromodichloromethane	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0016	< 0.0005	0.010
Chloroform	0.0015	0.0019	0.0025	0.00070	0.00055	< 0.0005	0.022	< 0.0005	0.07
Cis-1,2-Dichloroethene	0.0021	0.0017	0.0015	0.0013	0.0031	< 0.0005	< 0.0005	< 0.0005	0.07
Dichlorodifluoromethane	0.00055	0.0017	0.00064	< 0.0005	0.00098	< 0.0005	< 0.0005	< 0.0005	1.0
Tetrachloroethene (PCE)	0.0041	0.0068	0.0066	0.0035	0.0071	< 0.0005	< 0.0005	< 0.0005	0.005
Trichloroethene (TCE)	0.0011	0.0017	0.0013	0.0011	0.0023	< 0.0005	< 0.0005	< 0.0005	0.005
Trichlorofluoromethane	< 0.0005	0.00053	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	10
o-Xylene	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.035	10 ⁽³⁾
Total Xylenes	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.035	10
Cyanide (Total)	< 0.003	0.005	0.030	< 0.003	< 0.0003	< 0.003	< 0.003	1.74	0.2
Chemical Oxygen Demand (COD)	< 4	< 4	< 4	< 4	< 4	< 4	7	27	NA

Concentrations are in mg/L, except as indicated.

NM = not measured

(1) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.

(2) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(3) GWPS is for Total Xylenes

Values in bold exceed the GWPS.

**TABLE 4-2. COMPARISON OF DOWNGRADIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR THE DECEMBER 2016 SAMPLING EVENT**

Parameter	December 2016 Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				GWPS ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
pH (s.u.)	5 / 5	7	7.24	7.3	7.4	HL-99-3	3 / 3	7.17	7.1	7.4	NA
Specific Conductance (µmhos/cm)	5 / 5	1000	1178	1260	1310	HL-10-1	3 / 3	1680	1300	2730	NA
Sulfate	5 / 5	130	<u>144</u>	<u>140</u>	<u>160</u>	HL-99-1	3 / 3	65	67	120	NA
Chloride	5 / 5	43	<u>65</u>	<u>67</u>	<u>100</u>	HL-99-3	3 / 3	40	36	59	NA
Nitrate+Nitrite as N	5 / 5	7.4	9.66	9.5	11.4	HL-10-1	3 / 3	8.81	8.8	15.8	10
Arsenic (Dissolved)	4 / 5	< 0.0010	0.0012	0.0010	0.002	HL-99-2	3 / 3	0.0023	0.002	0.003	0.010
Barium (Dissolved)	5 / 5	0.041	0.061	<u>0.067</u>	<u>0.076</u>	HL-10-1	3 / 3	0.052	0.05	0.066	1.0
Cadmium (Dissolved)	0 / 5	< 0.00003	< 0.00003	< 0.00003	< 0.00003	NA	1 / 3	0.000040	< 0.00003	0.00006	0.005
Copper (Dissolved)	2 / 5	< 0.002	<u>0.0032</u>	< 0.002	<u>0.007</u>	HL-99-1	1 / 3	0.0020	< 0.002	0.002	1.3
Iron (Dissolved)	3 / 5	< 0.02	0.044	0.02	0.14	HL-99-2	1 / 3	0.27	< 0.02	0.76	0.3 ⁽⁶⁾
Lead (Dissolved)	1 / 5	< 0.0003	<u>0.00040</u>	< 0.0003	<u>0.0008</u>	HL-99-1	0 / 3	< 0.00030	< 0.0003	< 0.0003	0.015
Mercury (Dissolved)	4 / 5	< 0.000005	<u>0.000064</u>	<u>0.000024</u>	<u>0.00024</u>	HL-10-1	1 / 3	0.0000059	< 0.000005	0.0000076	0.002
Nickel (Dissolved)	1 / 5	< 0.002	0.0022	< 0.002	0.003	HL-99-1	1 / 3	0.0047	< 0.002	0.01	0.10
Selenium (Dissolved)	0 / 5	< 0.001	< 0.001	< 0.001	< 0.001	NA	2 / 3	0.0043	0.005	0.007	0.05
Zinc (Dissolved)	1 / 5	< 0.008	<u>0.0090</u>	< 0.008	<u>0.013</u>	HL-99-1	0 / 3	< 0.008	< 0.008	< 0.008	2.0
1,1,1-Trichloroethane	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.0010	< 0.0005	0.0021	0.2
1,1-Dichloroethane	5 / 5	<u>0.00088</u>	<u>0.0022</u>	<u>0.0019</u>	<u>0.0038</u>	HL-99-2	0 / 3	< 0.0005	< 0.0005	< 0.0005	NA
Benzene	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.294	< 0.0005	0.882	0.005
Bromodichloromethane	0 / 5	< 0.0005	< 0.0005	< 0.0005	< 0.0005	N/A	1 / 3	0.0009	0.005	0.0005	0.01
Chloroform	5 / 5	0.00055	<u>0.001</u>	0.0015	<u>0.0025</u>	HL-99-3	1 / 3	0.0077	< 0.0005	0.022	0.07
Cis-1,2-Dichloroethene	5 / 5	<u>0.0013</u>	<u>0.0019</u>	<u>0.0017</u>	<u>0.0031</u>	HL-10-1	0 / 3	< 0.0005	< 0.0005	< 0.0005	0.07
Dichlorodifluoromethane	4 / 5	< 0.0005	<u>0.00087</u>	<u>0.00064</u>	<u>0.0017</u>	HL-99-2	0 / 3	< 0.0005	< 0.0005	< 0.0005	1
Tetrachloroethene (PCE)	5 / 5	<u>0.0035</u>	<u>0.0056</u>	<u>0.0066</u>	<u>0.0071</u>	HL-10-1	0 / 3	< 0.0005	< 0.0005	< 0.0005	0.005
Trichloroethene (TCE)	5 / 5	<u>0.0011</u>	<u>0.0015</u>	<u>0.0013</u>	<u>0.0023</u>	HL-10-1	0 / 3	< 0.0005	< 0.0005	< 0.0005	0.005
Trichlorofluoromethane	1 / 5	< 0.0005	<u>0.00051</u>	< 0.0005	<u>0.00053</u>	HL-99-2	0 / 3	< 0.0005	< 0.0005	< 0.0005	0.005
o-Xylene	0 / 5	< 0.0005	< 0.00050	< 0.0005	< 0.0005	N/A	1 / 3	0.012	< 0.0005	0.035	10 ⁽⁷⁾
Total Xylenes	0 / 5	< 0.0005	< 0.00050	< 0.0005	< 0.0005	N/A	1 / 3	0.012	< 0.0005	0.035	10
Cyanide (Total)	2 / 5	< 0.0003	0.0083	< 0.003	0.03	HL-99-3	1 / 3	0.58	< 0.003	1.7	0.2
Chemical Oxygen Demand (COD)	0 / 5	< 4	< 4	< 4	< 4	NA	2 / 3	12.7	7	27	NA

(1) Downgradient wells are: HL-90-1, HL-99-1, HL-99-2, HL-99-3, HL-10-1.

(2) Background / Upgradient wells are: HL-06-1, HL-94-1R, MPC-5.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) GWPS is for Total Xylenes

Values in **bold** exceed the MCL. Underlined values exceed the maximum background/upgradient concentration.

**TABLE 4-3. COMPARISON OF DOWNGRAIENT CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS
AND MCLs FOR ALL SAMPLING EVENTS TO DATE**

Parameter	Period of Record Downgradient Well Concentrations (mg/L) ⁽¹⁾						Comparison Values (mg/L)				
	D.F. ⁽³⁾	Min.	Mean ⁽⁴⁾	Median	Max.	Max. Location	Background / Upgradient Wells ⁽²⁾				GWPS ⁽⁵⁾
							D.F. ⁽³⁾	Mean ⁽⁴⁾	Median	Max.	
pH (s.u.)	150 / 150	6.9	7.41	7.4	8.0	HL-99-3	103 / 103	7.33	7.3	8.0	NA
Specific Conductance (µmhos/cm)	146 / 146	710	1035	999.5	1470	HL-10-01	102 / 102	1658	1145	4170	NA
Sulfate	149 / 150	15	138.9	137	190	HL-99-1	103 / 103	355.6	136	1980	NA
Chloride	150 / 150	29	57.7	46	190	HL-10-01	102 / 103	31.0	26	120	NA
Nitrate+Nitrite as N	146 / 146	2.61	8.31	8.5	16.6	HL-99-3	103 / 103	11.8	7.26	73	10
Arsenic (Dissolved)	35 / 150	< 0.001	0.0043	< 0.005	0.01	HL-99-3	42 / 104	0.0050	< 0.005	0.037	0.010
Barium (Dissolved)	36 / 150	0.04	0.091	< 0.1	0.1	HL-10-01	27 / 104	0.088	< 0.1	0.1	1.0
Cadmium (Dissolved)	6 / 151	< 0.00003	0.00082	< 0.001	<u>0.005</u>	HL-90-1	12 / 104	0.00079	< 0.001	0.002	0.005
Copper (Dissolved)	12 / 146	< 0.002	0.0082	< 0.01	0.010	HL-10-01	9 / 104	0.0083	< 0.01	0.02	1.3
Iron (Dissolved)	48 / 150	< 0.02	0.080	< 0.03	1.0	HL-99-1	40 / 103	0.47	< 0.03	3.14	0.3 ⁽⁶⁾
Lead (Dissolved)	4 / 151	< 0.0003	0.0078	< 0.01	0.02	HL-90-1	1 / 104	0.0077	< 0.01	0.01	0.015
Mercury (Dissolved)	34 / 150	< 0.000005	0.00078	< 0.001	0.0010	HL-10-01	9 / 104	0.00075	< 0.001	0.0010	0.002
Nickel (Dissolved)	1 / 145	< 0.002	< 0.008	< 0.01	< 0.01	HL-10-01	32 / 104	0.010	< 0.01	0.05	0.10
Selenium (Dissolved)	10 / 150	< 0.001	0.0041	< 0.005	0.006	HL-99-2	50 / 104	0.0054	< 0.005	0.013	0.05
Zinc (Dissolved)	26 / 146	< 0.008	0.011	< 0.01	<u>0.09</u>	HL-90-1	8 / 104	0.010	< 0.01	0.02	2.0
1,1,1-Trichloroethane	43 / 220	< 0.0002	0.0013	< 0.001	<u>0.0074</u>	HL-90-1	21 / 108	0.0013	< 0.001	0.0057	0.2
1,1-Dichloroethane	182 / 220	0.00068	<u>0.0021</u>	<u>0.002</u>	<u>0.0052</u>	HL-99-3	0 / 108	< 0.001	< 0.001	< 0.001	NA
Benzene	0 / 220	< 0.0005	< 0.0009	< 0.001	< 0.001	N/A	37 / 108	0.119	< 0.001	4.65	0.005
Bromodichloromethane	0 / 220	< 0.0005	< 0.0009	< 0.001	< 0.001	N/A	22 / 108	0.0013	< 0.001	0.0048	0.01
Chloroform	194 / 220	0.00055	0.0022	0.0021	0.0055	HL-90-1	81 / 108	0.0068	0.0033	0.037	0.07
Cis-1,2-Dichloroethene	94 / 215	0.00051	<u>0.0013</u>	< 0.001	<u>0.0032</u>	HL-10-01	0 / 108	< 0.001	< 0.001	< 0.001	0.07
Dichlorodifluoromethane	155 / 220	< 0.0005	<u>0.0018</u>	<u>0.0013</u>	<u>0.015</u>	HL-90-1	0 / 108	< 0.001	< 0.001	< 0.001	1
Tetrachloroethene (PCE)	218 / 220	< 0.001	<u>0.0067</u>	<u>0.0059</u>	<u>0.024</u>	HL-99-3	1 / 108	0.00089	< 0.001	0.001	0.005
Trichloroethene (TCE)	140 / 220	0.00067	<u>0.0013</u>	<u>0.0011</u>	<u>0.0032</u>	HL-99-3	0 / 108	< 0.001	< 0.001	< 0.001	0.005
Trichlorofluoromethane	29 / 220	< 0.0005	0.0010	< 0.001	0.0044	HL-99-3	0 / 108	< 0.001	< 0.001	< 0.001	10
o-Xylene	0 / 215	< 0.0005	0.00092	< 0.001	< <u>0.0010</u>	N/A	38 / 108	< 0.014	< 0.001	0.422	10 ⁽⁷⁾
Total Xylenes	1 / 121	< 0.0005	0.00086	< 0.001	0.0013	HL-90-1	21 / 70	< 0.030	< 0.001	0.93	10
Cyanide (Total)	55 / 150	< 0.003	0.013	< 0.005	0.4	HL-99-2	38 / 104	1.76	< 0.005	10.9	0.2
Chemical Oxygen Demand (COD)	90 / 149	< 0.3	3.22	3	25	HL-99-3	90 / 103	17.6	8	75	NA

(1) Downgradient wells are: HL-10-1, HL-90-1, HL-99-1, HL-99-2, HL-99-3.

(2) Background / Upgradient wells are: HL-06-1, MPC-5, HL-94-1, HL-94-1R.

(3) Detection frequency (D.F.), i.e. the number of detections over the total number of samples analyzed for that parameter.

(4) Means calculated using the detection limit for non-detected sample results.

(5) Groundwater protection standard (human health standard) established by MDEQ in Circular DEQ-7. Values are generally equivalent to federally promulgated Maximum Contaminant Levels (MCLs) under the Safe Drinking Water Act. NA indicates no groundwater human health standard is established in Circular DEQ-7.

(6) Secondary Maximum Contaminant Level based on aesthetic properties such as taste, odor, and staining.

(7) GWPS is for Total Xylenes

Values in **bold** exceed the GWPS. Underlined values exceed the maximum background/upgradient concentration.

- (e) Nitrate was detected in all of the December 2016 samples. The MCL of 10.0 mg/L was exceeded in three samples; one collected in upgradient well MPC-5 and two in downgradient wells HL-99-1 and HL-10-1. Monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a decrease in the nitrate concentration in this well and is currently at a level of 15.8 mg/L. Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentration in area groundwater. This pilot program was shut down when these adverse effects became apparent. However, nitrate levels in downgradient wells have shown a corresponding increase over time.
- (f) Metals and arsenic concentrations in groundwater samples have historically been low (typically below laboratory detection limits). The recent implementation of lower detection limits has increased the frequency of metals detections in all wells. Arsenic and barium were detected in all samples both upgradient and downgradient; cadmium was detected only in upgradient well MPC-5; copper was detected in downgradient wells HL-99-1 and HL-99-3 and upgradient well MPC-5; iron was detected in downgradient wells HL-99-2, HL-99-3, and HL-10-1 and upgradient well MPC-5; lead and zinc were detected only in downgradient well HL-99-1; mercury was detected in upgradient well MPC-5 and in all downgradient wells except HL-90-1; nickel was detected in a downgradient well for the first time in well HL-99-1 and in upgradient well MPC-5; and selenium was detected in upgradient wells HL-94-1R and MPC-5 during December 2016 monitoring (Table 4-1). The detected metal concentrations were all at or near their detection limits except for barium in all wells, ranging from 0.040 mg/L to 0.076 mg/L compared with a detection limit of 0.003 mg/L; mercury in four downgradient wells ranging from 0.0000179 mg/L to 0.000310 mg/L compared to a detection limit of 0.000005 mg/L; and iron in downgradient well HL-99-2 (0.14 mg/L) and upgradient well MPC-5 (0.76 mg/L) compared to a detection limit of 0.02 mg/L. All detections were below the primary MCL values for their respective parameters. Iron exceeded the secondary MCL of 0.3 mg/L (based on aesthetic properties such as taste, odor and staining rather than

human health standards) in MPC-5. Iron has historically fluctuated at MPC-5 with concentrations ranging from approximately 0.2 mg/L to 4 mg/L (based on data collected from December 1995 through December 2016).

(g) During the December 2016 sampling event, several volatile organic compounds (VOCs) were detected in samples from downgradient wells, but not in samples from background wells (1,1-dichloroethane, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane). PCE exceeded the MCL in downgradient wells HL-99-2, HL-99-3, and HL-10-1. The parameters 1,1,1-trichloroethane, benzene, bromodichloromethane, o-xylenes, and total xylenes were detected only in background wells; benzene was the only VOC to exceed its MCL in an upgradient well (MPC-5). Chloroform was the only VOC detected in samples from both downgradient and background wells; all detections of chloroform were well below the MCL of 0.07 mg/L.

(h) Cyanide was detected in two downgradient wells (HL-99-2 and HL-99-3) and one upgradient well (MPC-5) during the December 2016 sampling event. The downgradient detections were well below the MCL of 0.2 mg/L; however, upgradient well MPC-5 far exceeded the MCL with a concentration of 1.74 mg/L.

Previous sampling events have shown that cyanide is present at concentrations ranging from approximately 0.77 to 11 mg/L (based on data collected from June 1995 through December 2016) in upgradient well MPC-5. Historically, downgradient detections of cyanide have been well below the MCL indicating that elevated cyanide levels are not attributable to the Helena Landfill (Table 4-3). As noted previously, a coal gasification plant was historically operated east of the landfill site and could be a source of residual cyanide in groundwater upgradient of the landfill.

4.2 INTER-WELL PREDICTION INTERVAL ANALYSES

Inter-well prediction interval analyses were used to test for statistically significant differences between background and compliance well concentrations for selected parameters (those above the detection limit in any of the monitoring wells for the December 2016 sampling event). Combining all historical data for the background wells, either the Shapiro-

Wilks test of normality ($n < 50$) or the Shapiro-Francia Test of Normality ($N > 50$) was performed for each parameter to determine the distribution of the background data. Inter-well parametric prediction intervals were used when the background data were normally or ln-normally distributed. In cases where the background data were not normally or ln-normally distributed, a non-parametric prediction limit was used. All non-detect values were evaluated at one half the detection limit for all parametric analyses. Results of the prediction interval test are summarized in Table 4-4. Documentation for each of these statistical tests used is included in Appendix B of this report.

As shown on Table 4-4, chloride, copper, lead, mercury, zinc, 1,1-dichloroethane, cis-1,2-dichloroethane, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane have statistically greater concentrations in downgradient wells than upgradient wells.

4.3 TREND ANALYSIS

In addition to evaluating the chemical concentrations in upgradient and downgradient wells around the landfill for the December 2016 sampling event, it is also important to evaluate concentration trends of key constituents over time. Using the Mann-Kendall test, statistical testing for trends was performed for each downgradient exceedance of its respective inter-well prediction interval as discussed in Section 4.2. All non-detect values were evaluated as zero to prevent the detection of false trends when parameters are detected at concentrations less than the reporting limit or when the reporting limits have changed over time. The results of these analyses are summarized in Table 4-5. Documentation for these statistical tests is included in Appendix B of this report.

Chloride is showing an increasing trend in well HL-90-1; there is no groundwater protection standard for chloride. Copper, lead, mercury, and zinc are showing increasing trends in well HL-99-1 and mercury is also increasing in well HL-10-1. Most of these increasing trends are a function of the decrease in laboratory reporting limits that became effective in 2012 and are not visibly apparent when viewed on a trend plot. 1,1-dichloroethane is showing an increasing trend in downgradient wells HL-99-2 and HL-10-1 and a decreasing trend in well

TABLE 4-4. RESULTS OF INTER-WELL PREDICTION INTERVAL TESTS

Parameter	Background Wells		HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1
	Distribution ⁽¹⁾	Prediction Limit ⁽²⁾					
pH (s.u.)	Non-Norm	6.9 - 7.9	7.2	7.3	7.4	7.3	7.0
Specific Conductance (µmhos/cm)	Non-Norm	4106	1280	1040	1000	1260	1310
Sulfate	Non-Norm	1855	160	130	140	130	160
Chloride	Non-Norm	85	69	43	48	100	67
Nitrate+Nitrite as N	ln-Norm (99%)	193	11.1	7.4	9.5	8.9	11.4
Arsenic (Dissolved)	Non-Norm	0.0040	0.001	0.002	0.001	0.001	0.001
Barium (Dissolved)	Norm (99%)	0.094	0.068	0.052	0.041	0.067	0.076
Cadmium (Dissolved)	Non-Norm	0.00013	0.00003	0.00003	0.00003	0.00003	0.00003
Copper (Dissolved)	Non-Norm	0.0030	0.007	0.002	0.003	0.002	0.002
Iron (Dissolved)	Non-Norm	1.52	0.02	0.14	0.02	0.02	0.02
Lead (Dissolved)	Non-Norm	0.0004	0.0008	0.0003	0.0003	0.0003	0.0003
Mercury (Dissolved)	Non-Norm	0.000029	0.000031	0.0000179	0.000024	0.000005	0.00024
Nickel (Dissolved)	Non-Norm	0.013	0.003	0.002	0.002	0.002	0.002
Selenium (Dissolved)	Norm (99%)	0.018	0.001	0.001	0.001	0.001	0.001
Zinc (Dissolved)	Non-Norm	0.008	0.013	0.008	0.008	0.008	0.008
1,1,1-Trichloroethane	Non-Norm	0.0054	0.0005	0.0005	0.0005	0.0005	0.0005
1,1-Dichloroethane	ND	0.0005	0.00088	0.0038	0.0019	0.0015	0.0027
Benzene	Non-Norm	2.30	0.0005	0.0005	0.0005	0.0005	0.0005
Bromodichloromethane	Non-Norm	0.0042	0.0005	0.0005	0.0005	0.0005	0.0005
Chloroform	Non-Norm	0.036	0.0015	0.0019	0.0025	0.0007	0.00055
Cis-1,2-Dichloroethene	ND	0.0005	0.0021	0.0017	0.0015	0.0013	0.0031
Dichlorodifluoromethane	ND	0.0005	0.00055	0.0017	0.00064	0.0005	0.00098
Tetrachloroethene (PCE)	Non-Norm	0.0012	0.0041	0.0068	0.0066	0.0035	0.0071
Trichloroethene (TCE)	ND	0.0005	0.0011	0.0017	0.0013	0.0011	0.0023
Trichlorofluoromethane	ND	0.0005	0.0005	0.00053	0.0005	0.0005	0.0005
o-Xylene	Non-Norm	0.169	0.0005	0.0005	0.0005	0.0005	0.0005
Total Xylenes	Non-Norm	0.428	0.0005	0.0005	0.0005	0.0005	0.0005
Cyanide (Total)	Non-Norm	10.6	0.003	0.005	0.03	0.003	0.0003
Chemical Oxygen Demand (COD)	Non-Norm	69.0	4	4	4	4	4

(1) Normality was calculated using the Shapiro-Wilks test (n<50) or Shapiro-Francia test (n>50). (Non-detects replaced with 1/2 detection limit.)

Norm (X%) = data normally distributed at X% level of significance.

ln-Norm (X%) = data ln-normally distributed at X% level of significance.

Non-Norm = data not normally or ln-normally distributed at 95% or 99% level of significance.

ND = all background data below detection limits. Value shown is the detection limit.

(2) Inter-well prediction limits calculated as follows with non-detects replaced with 1/2 detection limit:

Normal or ln-normal distribution: parametric prediction interval (99% one-sided, two-sided for pH)

Non-normal distribution: non-parametric prediction interval (99% one-sided, two-sided for pH)

ND: any detectable concentrations in compliance wells are considered significant.

Bold values indicate statistically significant results.

HL-90-1; this compound is a breakdown product of 1,1,1-trichloroethane, historically found in both upgradient and downgradient wells. Cis-1,2-dichloroethane is showing an increasing trend in wells HL-99-2, HL-99-3, HL-90-1, and HL-10-1; this compound is formed as a breakdown product of TCE and PCE. Dichlorodifluoromethane is showing a decreasing trend in downgradient well HL-99-3. PCE is showing decreasing trends in wells HL-99-1, HL-99-3, and HL-90-1. TCE is showing an increasing trend in wells HL-99-1, HL-99-2, and HL-10-1, but a decreasing trend in HL-90-1. PCE and TCE are common industrial solvents.

TABLE 4-5. RESULTS OF MANN-KENDALL TREND ANALYSES

Parameter	HL-99-1	HL-99-2	HL-99-3	HL-90-1	HL-10-1
Chloride				Increasing	
Copper	Increasing				
Lead	Increasing				
Mercury	Increasing				Increasing
Zinc	Increasing				
1,1-Dichloroethane	No Trend	Increasing	No Trend	Decreasing	Increasing
Chloroform					No Trend
Cis-1,2-Dichloroethane	No Trend	Increasing	Increasing	Increasing	No Trend
Dichlorodifluoromethane	No Trend	No Trend	Decreasing		No Trend
Tetrachloroethene (PCE)	Decreasing	No Trend	Decreasing	Decreasing	No Trend
Trichloroethene (TCE)	Increasing	Increasing	No Trend	Decreasing	Increasing
Trichlorofluoromethane		No Trend			

*Grayed boxes did not have downgradient exceedances of the respective inter-well prediction interval and therefore a trend analysis was not performed. NA = not enough data was available at lower detection limit to perform a trend analysis.

4.4 TEMPORAL CONCENTRATION PLOTS

This report focuses on concentration trends for PCE and nitrate because they are the only constituents exceeding their MCLs in downgradient monitoring wells. PCE was also the focus of the Corrective Measures Assessment for the landfill (Hydrometrics, 1995).

In an attempt to reduce concentrations of PCE in compliance well HL-90-1, the City installed a groundwater extraction system in the spring of 2000 (Hydrometrics, 1999b). This treatment system involves pumping wells HL-99-1, HL-99-2, and HL-99-3 to intercept PCE leaving the landfill, and treating the water to remove VOCs prior to land application on Bill Roberts Golf Course. These wells have been included in groundwater monitoring events

along with compliance wells HL-90-1 and HL-10-1, to evaluate the progress of this new groundwater extraction system.

Trends in PCE concentrations over time for the past several years for selected monitoring wells are shown on Figure 4-1. PCE concentrations exceeded the MCL value of 0.005 mg/L in monitoring wells HL-99-2, HL-99-3, and HL-10-1 for December 2016. Historically, the PCE concentrations in pumping wells HL-99-1, HL-99-2, and HL-99-3 have shown seasonal fluctuations and decreasing trends over the last several years. Compliance well HL-90-1 has shown definite improvement since the installation of the groundwater extraction system in June 2000, averaging 0.0146 mg/L before the extraction system and 0.0069 mg/L after. Due to low water levels in well HL-90-1, a new, deeper well HL-10-1 was installed near HL-90-1. PCE concentrations in this new well range from 0.006 mg/L to 0.0082 mg/L from June 2010 to the December 2016 sampling event, within historical range of HL-90-1 values, and show neither an increasing or decreasing trend during statistical analysis (Section 4.3). Extraction wells HL-99-1 and HL-99-3 immediately upgradient of compliance well HL-10-1 and compliance well HL-90-1 immediately adjacent to well HL-10-1 are all showing statistically decreasing PCE trends.

Nitrate concentrations in all downgradient monitoring wells and upgradient wells HL-94-1R and MPC-5 are shown on Figure 4-2. The concentrations of nitrate in downgradient wells HL-90-1, HL-99-2, and HL-99-3 have shown no trend or slightly decreasing trends for the last ten years. Wells HL-99-1 and HL-10-1 have shown a slightly increasing nitrate trend and are currently just over the MCL at 11.1 mg/L and 11.4 mg/L, respectively.

Historically, upgradient wells have shown the highest levels of nitrate in groundwater (Figure 4-2). Upgradient monitoring well MPC-5 showed an increasing trend from 1998 through 2005 reaching a maximum of 73.0 mg/L. Since then, there has been a generally decreasing trend in the nitrate concentration in this well with the December 2016 concentration at 15.8 mg/L. Upgradient well HL-94-1R has also shown a generally increasing nitrate trend over the last ten years reaching a maximum of 20.0 mg/L in June 2016 and is currently at 13.2 mg/L.

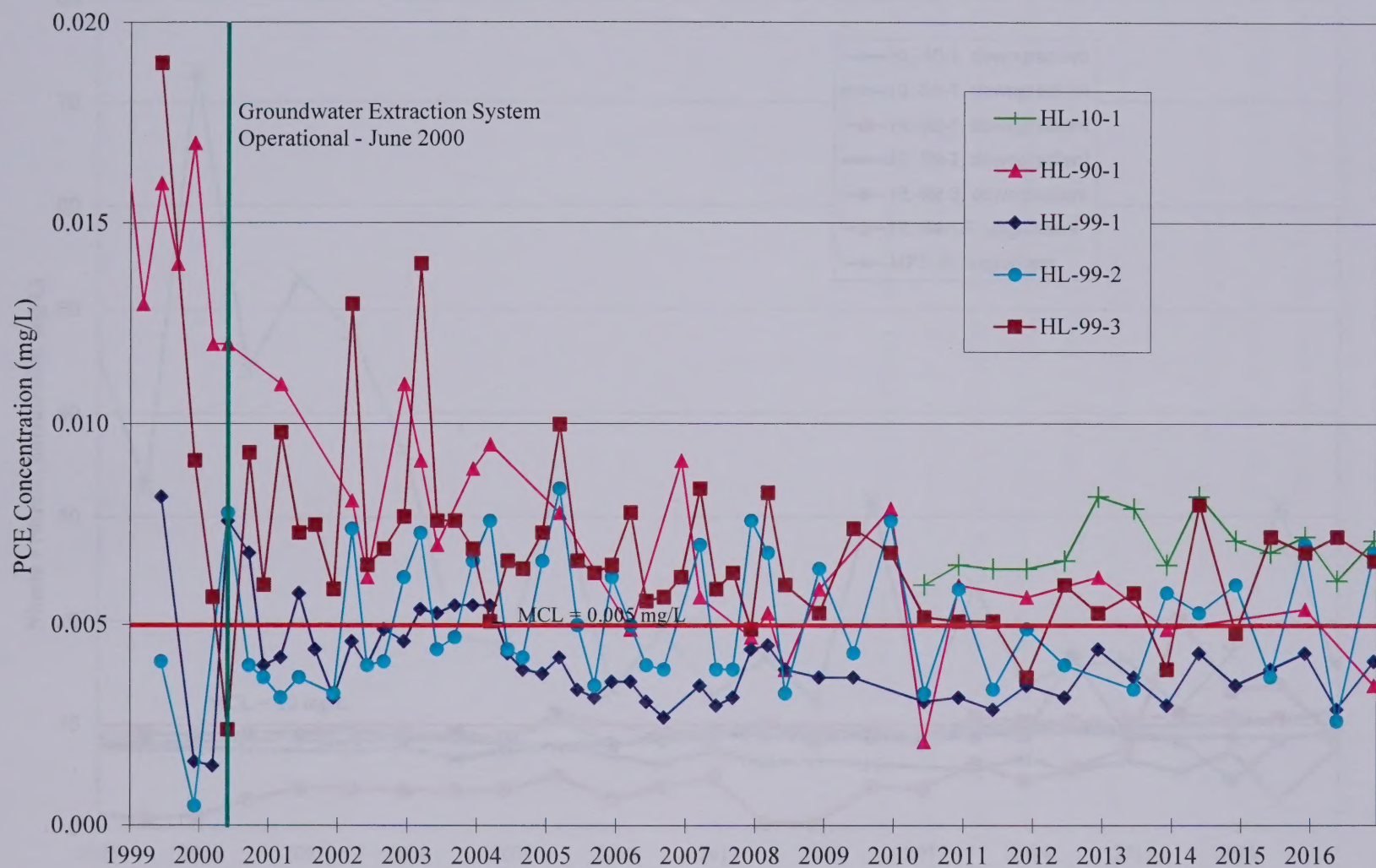


Figure 4-1. Temporal Trends in Tetrachloroethene Concentrations at Selected Monitoring Wells

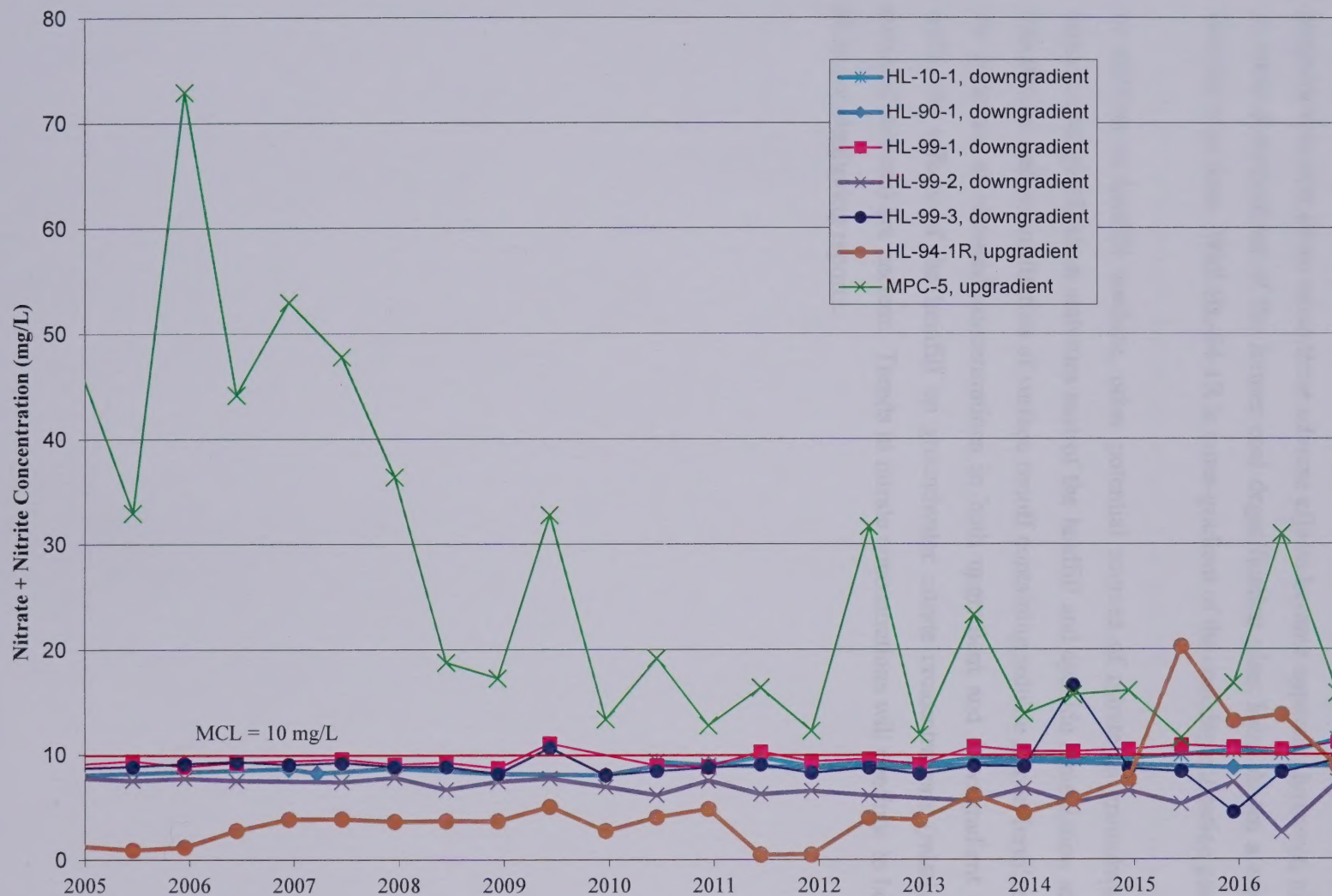


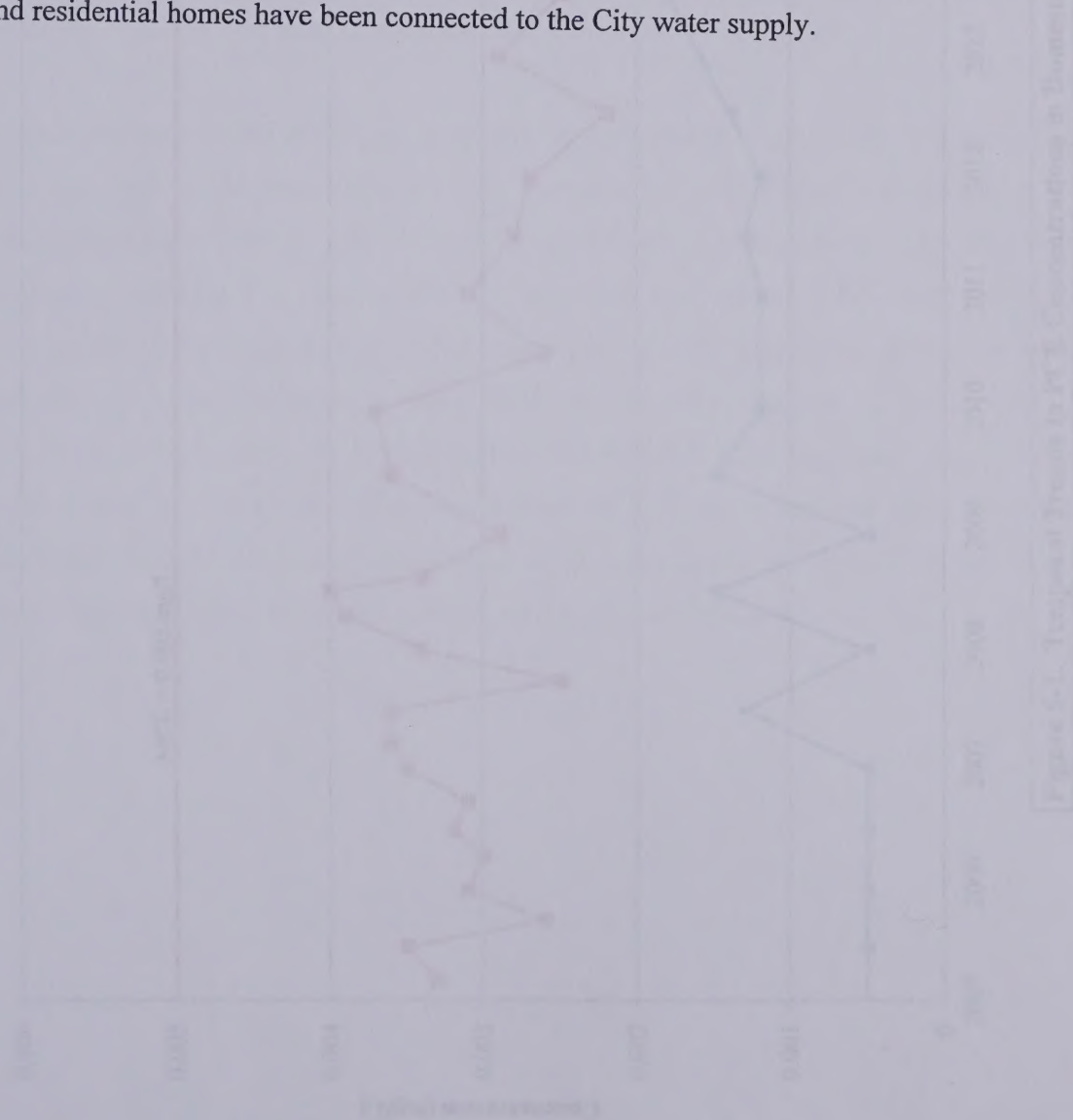
Figure 4-2. Temporal Trends in Nitrate Concentrations at Selected Monitoring Wells

Discussions with MPC representatives revealed that an attempt to remediate cyanide (from a historic coal gasification plant that was operated just east of the landfill) through oxidation may have inadvertently increased nitrate concentrations in area groundwater. This pilot program was shut down when these adverse effects became apparent; however, nitrate levels in wells downgradient of the former coal degasification plant have shown a corresponding increase over time. Well HL-94-1R is cross-gradient of the coal degasification plant.

In addition to landfill leachate, other potential sources of nitrate in groundwater include historic coal gasification activities east of the landfill and cyanide remediation activities for this site, as well as infiltration of surface runoff containing soluble nitrate fertilizers. Due to the presence of elevated concentrations in both upgradient and downgradient monitoring wells, the effects of the landfill on groundwater nitrate concentrations (relative to other potential sources) are unclear. Trends in nitrate concentrations will continue to be evaluated in future monitoring reports.

5. DOMESTIC WELL DATA EVALUATION

Two domestic wells were also included in the December 2016 sampling event. For well 5, the only concentrations of VOCs reported above the detection limit were for 1,1-dichloroethane, chloroform, PCE, and TCE; all detections were below their respective MCLs. PCE concentrations over the last ten years for domestic well 5 are shown on Figure 5-1 and show an overall decreasing trend. For well 16, the only VOCs with reported concentrations above the detection limit were 1,1-dichloroethane, chloroform, and PCE; all detections were below their respective MCLs. PCE concentrations for this well are shown on Figure 5-1 and show an increasing trend. All wells in these areas are used only for irrigation, and residential homes have been connected to the City water supply.



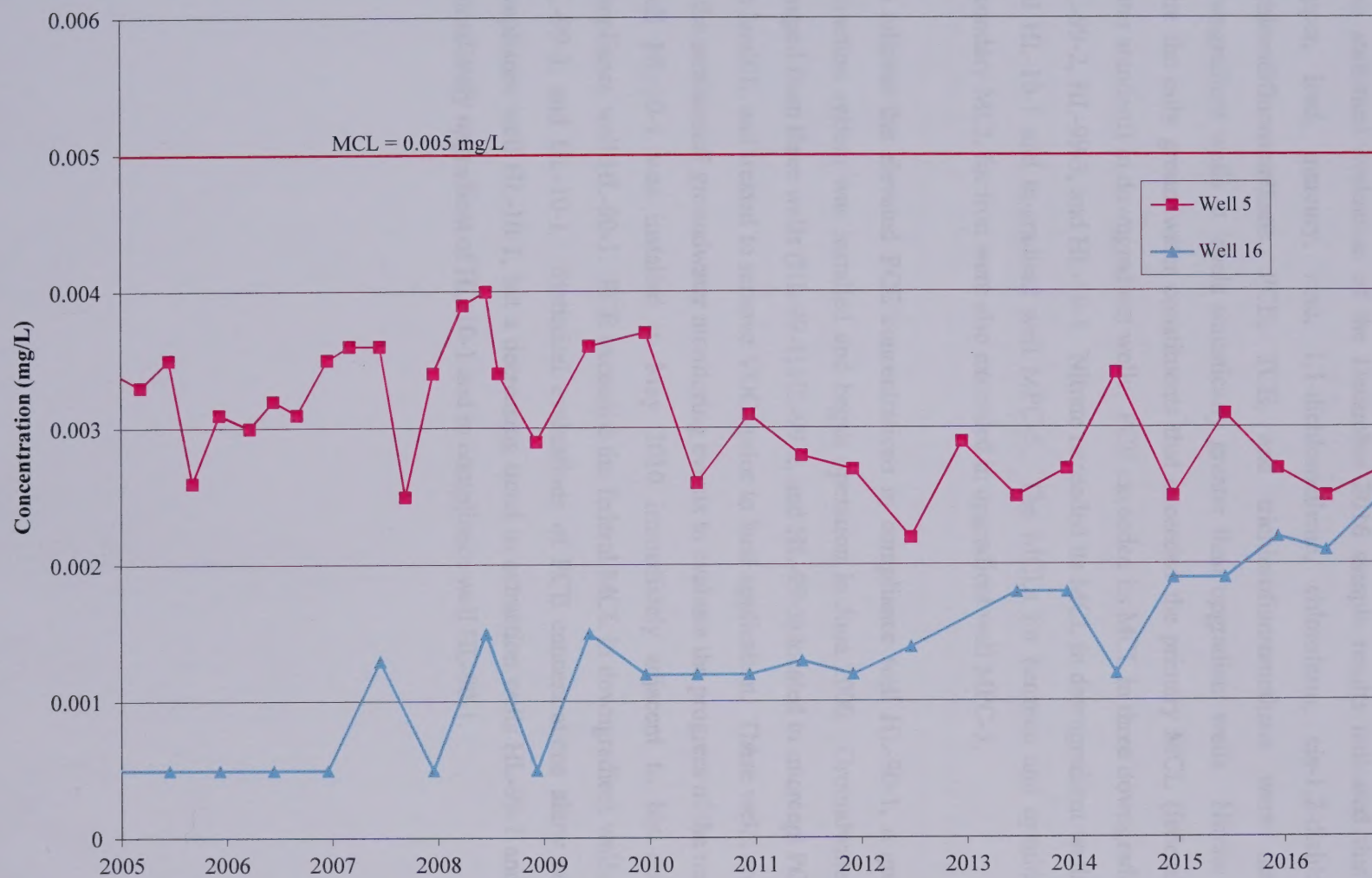


Figure 5-1. Temporal Trends in PCE Concentrations in Domestic Wells

6. SUMMARY AND CONCLUSIONS

This statistical evaluation of the December 2016 sample results indicated that chloride, copper, lead, mercury, zinc, 1,1-dichloroethene, chloroform, cis-1,2-dichloroethene, dichlorodifluoromethane, PCE, TCE, and trichlorofluoromethane were detected in downgradient wells at levels statistically greater than upgradient wells. Nitrate and PCE were the only groundwater constituents that exceeded the primary MCL (federal drinking water standard) in downgradient wells. PCE exceeded its MCL in three downgradient wells, HL-99-2, HL-99-3, and HL-10-1. Nitrate exceeded its MCL in downgradient wells HL-99-1 and HL-10-1 and upgradient well MPC-5. The MCLs for benzene and cyanide and the secondary MCL for iron were also exceeded in upgradient well MPC-5.

To address the elevated PCE concentrations in compliance well HL-90-1, a groundwater extraction system was installed and began operation in June 2000. Groundwater is being pumped from three wells (HL-99-1, HL-99-2, and HL-99-3) located to intercept PCE leaving the landfill, and treated to remove VOCs prior to land application. These wells are included in the semiannual groundwater monitoring events to evaluate the progress of the new system. Well HL-10-1 was installed in May 2010 immediately adjacent to but deeper than compliance well HL-90-1. PCE exceeded the federal MCL in downgradient wells HL-99-2, HL-99-3, and HL-10-1. Statistical evaluations of PCE concentrations show no trend in compliance well HL-10-1, but a decreasing trend in extraction wells HL-99-1 and HL-99-3 immediately upgradient of HL-10-1 and in compliance well HL-90-1.

7. REFERENCES

- EPA, 1989. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities - Interim Final Guidance, PB89-151047, February 1989.
- EPA, 1992. Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities - Addendum to Interim Final Guidance, Draft, Office of Solid Waste, Permits and State Programs Division, July 1992.
- Hydrometrics, Inc., 1995. Corrective Measures Assessment, City of Helena Landfill, Helena, Montana, Prepared for City of Helena, February 1995.
- Hydrometrics, Inc., 1999a. Evaluation of Groundwater Extraction Remediation Alternative at the Helena Landfill, Prepared for the City of Helena, August 1999.
- Hydrometrics, Inc., 1999b. Contract Documents and Specifications for Helena Landfill Groundwater Extraction City, City of Helena Project No. 99-15, Prepared for City of Helena, September 1999.
- Hydrometrics, Inc., 2008. Revised Sampling and Analysis Plan, City of Helena Landfill, Groundwater, Surface Water and Landfill Gas Monitoring Activities, Prepared for City of Helena, March 2008.

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DATA VALIDATION REPORT CITY OF HELENA LANDFILL

Groundwater Samples Collected in

December 2016

(Semi-Annual Sampling)

Prepared by
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FEBRUARY 2017

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SUMMARY

Laboratory analysis for groundwater samples collected for the December 2016 sampling event at east of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised City of Helena Landfill Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydroactivities, March 2005). All samples were analyzed for the following parameters:

GLOSSARY OF TERMS

CCB.....	Continuing Calibration Blank
CCV	Continuing Calibration Verification
CLP	Contract Laboratory Program
CRDL.....	Contract Required Detection Limit
FAA	Flame Atomic Absorption
GFAA.....	Graphite Furnace Atomic Absorption
HGAA	Hydride Generation Atomic Absorption
ICB	Initial Calibration Blank
ICP	Inductively Coupled Plasma
ICV.....	Initial Calibration Verification
IDL.....	Instrument Detection Limit
LCS	Laboratory Control Sample
MSA.....	Method of Standard Additions
PB.....	Preparation Blank
PRDL	Project Required Detection Limit
QAPP	Quality Assurance Project Plan
QC.....	Quality Control
RPD.....	Relative Percent Difference
RSD.....	Relative Standard Deviation
SOW.....	Statement of Work
TDS.....	Total Dissolved Solids

SUMMARY

Laboratory analysis for groundwater samples collected for the December 2016 sampling event as part of the City of Helena Landfill have been reviewed and validated. This review has been in accordance with the "Revised Sampling and Analysis Plan; City of Helena Landfill; Groundwater, Surface Water, and Landfill Gas Monitoring Activities" (Hydrometrics, March 2008). All samples were analyzed at Energy Laboratories in Helena, Montana.

Data results are qualified when associated field quality control samples have not met validation criteria. Not all quality control deficiencies are equally serious and some may not have any practical impact on the usefulness of the data. A summary of quality control violations found in this validation follows:

Violations involving field quality control samples:

- It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book or sampling forms.

Violations involving laboratory quality control samples:

- In the QA/QC Summary Reports provided by Energy Laboratories, there were several QA/QC exceedances. However, at this level of validation, laboratory exceedances are noted but no flagging of the data occurs.
- It should be noted that the reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis.
- It should be noted that Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.
- Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances.
- Sample HL-1612-110 (H16120303-011) was analyzed on 12/22 at a 150x dilution, and on 12/23 at a 10x dilution. The sample was re-analyzed at a 10x and 150x dilution on

1/4/17. The re-analysis confirmed the 10x dilution from 12/23 for all analytes except o-xylene. For o-xylene the value of 33 ug/L confirmed, with the J value from the 150x dilution on 12/22 and the 10x/150x dilution from 1/4/17. The confirmation analysis was past the method recommended hold time. The report was revised to include the results of the analysis for o-xylene from 1/4/17 per request from E. Vallance.

Deviations from the prescribed quality control procedures and/or exceedances of quality control limits have been noted, and results have been flagged in the database. The data quality objectives for accuracy and precision were met, as 100 percent of the field quality control sample results were within control limits and 99 percent of the laboratory quality control samples were within limits. The frequency requirements of 10 percent submittal of blanks, duplicates, control standards and spikes were met. The recommended project completeness goal, acceptance of 90 percent of the results as valid, has also been met as no results have been rejected as a result of this review. Further discussion of data quality objectives is in Section 12 of the data validation report. All tables are in Appendix 1: data validation codes and definitions are listed in Table 1; and a historical comparison is in Table 2. A database printout of this sampling event is located in Appendix 2. The Hydrometrics field notes are in Appendix 3. Energy Laboratories Analytical Reports are located in Appendix 4.

DATA VALIDATION REPORT

1. INTRODUCTION

This validation applies to organic and inorganic analyses for 14 water samples collected for the City of Helena Landfill semi-annual monitoring project during the December 2016 sampling event. The total number of samples included: one field duplicate, two field blanks (DI and Rinsate), one trip blank, ten non-QC water samples and 0 field observations.

All samples were submitted for volatile organic analyses, and select samples were submitted for inorganic analyses (metals and wet chemistry) as follows:

SITE CODE	SAMPLE NUMBER	WATER LEVEL	FIELD PARAMETERS ¹	METALS / COMMONS ²	VOLATILES METHOD 8260 ³
HL-06-1	HL-1612-107	X	X	X	X
HL-10-01	HL-1612-108	X	X	X	X
HL-10-01 DUP	HL-1612-109			X	X
HL-90-1	HL-1612-105	X	X	X	X
HL-94-1R	HL-1612-104	X	X	X	X
HL-99-1	HL-1612-101	X	X	X	X
HL-99-2	HL-1612-102	X	X	X	X
HL-99-3	HL-1612-103	X	X	X	X
MPC-5	HL-1612-110	X	X	X	X
#5	HL-1612-100		X		X
#16	HL-1612-106		X		X
DI BLANK	HL-1612-111			X	X
RINSATE BLANK	HL-1612-112			X	X
TRIP BLANK	HL-1612-113				X

- 1.) Field parameters include pH, SC, and water temperature.
- 2.) Metals and commons include those compounds listed in the first half of ARM 17.50.708 Table 1.
- 3.) Volatile organic compounds include those listed in the second half of ARM 17.50.708 Table 1.

- Validation procedures used are generally consistent with:
(Check all that apply)
☒ EPA CLP National Functional Guidelines for Inorganics Data Review
☒ EPA CLP National Functional Guidelines for Organic Data Review
☒ Work Plan (Sampling and Analysis Plan, City of Helena Landfill Groundwater Monitoring Activities, Hydrometrics, March 2008)
- Overall level of validation:
☐ Contract Laboratory Program (CLP)
☒ Standard (see following Notes)
☐ Visual
Notes: The review of this data includes checking all field and laboratory quality control samples; flagging for exceedances in field quality control; and calculating precision, accuracy, and completeness for both laboratory and field quality control samples.

2. DELIVERABLES

- All laboratory document deliverables were present as specified in the CLP-Statement of Work (CLP-SOW), EPA, 1993 and/or the project contract.
☒ Yes (see following notes)
☐ No
- All documentation of field procedures was provided as required.
☒ Yes
☐ No
Notes: Sample HL-1612-110 (H16120303-011) was analyzed on 12/22 at a 150x dilution, and on 12/23 at a 10x dilution. The sample was re-analyzed at a 10x and 150x dilution on 1/4/17. The re-analysis confirmed the 10x dilution from 12/23 for all analytes except o-xylene. For o-xylene the value of 33 ug/L confirmed, with the J value from the 150x dilution on 12/22 and the 10x/150x dilution from 1/4/17. The confirmation analysis was past the method recommended hold time. The report was revised to include the results of the analysis for o-xylene from 1/4/17 per request from E. Vallance.
- Consistency with project requirements
 Sampling was completed in order as stated in the SAP.
☒ Yes (see following Notes)
☐ No
Notes: It should be noted that the wells were not sampled in the order listed in the SAP. The order of sampling was followed for all wells that do not use dedicated or disposable equipment. Any variances in sampling order were noted in the field book.

3. FIELD QUALITY CONTROL SAMPLES

- Field blanks
 Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.
 DI, trip, rinseate, or any other field blanks have been carried out at the proper frequency.
☒ Yes
☐ No

Reported results on the field blanks are less than the contract required detection limits (CRDL) or the project required detection limits (PRDL) if project detection limits have been specified.

☒ Yes

☐ No

- **Field duplicates**

Field duplicates have been collected at the proper frequency.

☒ Yes

☐ No

Field duplicate relative percent differences (RPD's) were within the required control limits (RPD of 20 percent or less for water matrix, 35 percent or less for soil matrix). If the sample or duplicate result is less than 5 times the PRDL, the RPD criteria are not used. In these cases, the difference between the sample and the duplicate results must be within $\pm$ the PRDL for water matrix, within ± 2 times the PRDL for soil matrix.

☒ Yes

☐ No

- **Field standards**

Field standards were sent at the proper frequency

☐ Yes

☐ No

☒ NA - Not required by the work plan.

4. LABORATORY PROCEDURES

- **Laboratory procedures followed**

☐ CLP-SOW

☒ SW-846

☒ Methods for Chemical Analysis of Water and Wastes

☐ XRF Standard Operating Procedures

☐ Other

- **Samples were received by the laboratory at the proper temperature**

☒ Yes

☐ No

- **Holding times met**

☐ Yes

☒ No (see the following Notes)

Notes: Energy Laboratories exceeded the holding time for pH for all samples submitted. However, as a rule holding times for laboratory pH measurements are frequently exceeded because measurements are typically not conducted "immediately", but rather as soon as practicable. Therefore, no qualifiers are applied for lab pH holding time exceedances in the database.

Sample HL-1612-110 (H16120303-011) was analyzed on 12/22 at a 150x dilution, and on 12/23 at a 10x dilution. The sample was re-analyzed at a 10x and 150x dilution on 1/4/17. The re-analysis confirmed the 10x dilution from 12/23 for all analytes except o-xylene. For o-xylene the value of 33 ug/L confirmed, with the J value from the 150x dilution on 12/22 and the 10x/150x dilution from 1/4/17. The confirmation analysis was past the method recommended hold time. The report was revised to include the results of the analysis for o-xylene from 1/4/17 per request from E. Vallance.

- **Consistency with project requirements**

Analyses were carried out as requested.

☒ Yes (see following Notes)

☐ No

Project specified methods were used.

☒ Yes (see following Notes)

☐ No

Notes: Energy Laboratories used a different method than stated in the work plan on the following parameters: pH, SC, cyanide and all dissolved metals. However, no associated data was flagged because the methods used are considered comparable to stated methods in the work plan.

5. DETECTION LIMITS

- Reporting detection limits met project required detection limits (PRDL).

☒ Yes (see following Notes)

☐ No

Notes: The reporting limits used for all metals analysis varied from the requested limits however the RLs used were lower than the requested limits, and did not seem to impact the results of the analysis. Various samples analyzed for nitrate + nitrite as n and cyanide were flagged with a D by the laboratory to indicate the reporting limit was increased due to sample matrix; this also did not impact results.

6. LABORATORY BLANKS

Please note that the highest blank value associated with any particular analyte is the blank value used for the flagging process.

- **Preparation/Method blanks**

Preparation/Method blanks were prepared and analyzed at the required frequency.

☒ Yes

☐ No

All analytes in the preparation blank were less than the CRDL (or PRDL if a project detection limit has been specified).

☒ Yes

☐ No

7. LABORATORY BLANK SPIKES

- **Blank Spikes**

Blank spikes (organics) were prepared and analyzed at the required frequency.

☒ Yes

☐ No

Blank spike recoveries were within control limits.

☒ Yes

☐ No

8. SURROGATE SPIKES

Surrogate spikes were prepared and analyzed at the required frequency.

☒ Yes
☐ No

Surrogate spike recoveries were within control limits.

☒ Yes
☐ No

9. MATRIX SPIKE /MATRIX SPIKE DUPLICATES (MS/MSD)

- Matrix spike samples were analyzed at the proper frequency.

☒ Yes
☐ No

Matrix spike recoveries were within control limits.

☐ Yes
☒ No (see following Notes)

Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

- Matrix spike duplicate samples were analyzed at the proper frequency.

☒ Yes
☐ No

Matrix spike duplicate RPD's were within control limits.

☐ Yes
☒ No (see following Notes)

Notes: Several matrix spike and matrix spike duplicate samples contained QC exceedances. At this level of validation, these exceedances are only noted and no associated data is qualified.

10. INTERPARAMETER RELATIONSHIPS

- The following relationships have been checked for all data from the December 2016 monitoring:

☒ Lab SC versus field SC
☒ Lab pH versus field pH

Lab SC versus field SC: A comparison of the field and lab SCs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

Lab pH versus field pH: A comparison of the field and lab pHs using a percent difference (%D) criteria for evaluation purposes. For this data set, the data were all found to be within acceptable limits.

11. HISTORICAL COMPARISON

Current sampling event data (December 2016) were compared to historical data. The data for the December 2016 sampling event compared well to the historic data.

12. DATA QUALITY OBJECTIVES

- Project data quality objectives (DQO's) met.

X Yes

 No

Accuracy

Accuracy for this project is the agreement between a measured value and a true value and is measured by the recoveries on the laboratory matrix spikes and laboratory control samples.

Accuracy for this sampling event was 99 percent.

Precision

Precision for this project is the degree of variability between duplicate measurements. Laboratory analytical variability is measured by laboratory duplicates; field duplicates are a measure of overall variability in both field sampling and laboratory techniques.

Laboratory precision was 99 percent for this sampling event.

Field precision was 100 percent for this sampling event.

Completeness

The target completeness for this project is 90 percent of the measurements valid (not rejected). This percentage is based on the number of valid measurements compared to the number of planned measurements. Completeness for this sampling event was 100 percent.

DATA VALIDATION REPORT

Prepared by: Ericka Vallance

Reviewed by: Jodi Bingham, P.E.

REFERENCES

- Hem, J.D., 1992. Study and Interpretation of the Chemical Characteristics of Natural Water, 3rd Edition. US Geological Survey Water Supply Paper 2254.
- Hydrometrics Project Work Plan. Sampling and Analysis Plan City of Helena Landfill Groundwater Monitoring Activities, March 2008.
- U.S. Environmental Protection Agency, 1990. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition.
- U.S. Environmental Protection Agency, 1993. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. October 2004.
- U.S. Environmental Protection Agency, 1994. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. October 2004.

Data Validation and Statistical
Evaluation of December 2016
Groundwater Quality Data

City of Helena Landfill

Appendix A - Data Validation (Appendices Only)

March 2017



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Consulting Scientists and Engineers

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APPENDIX B

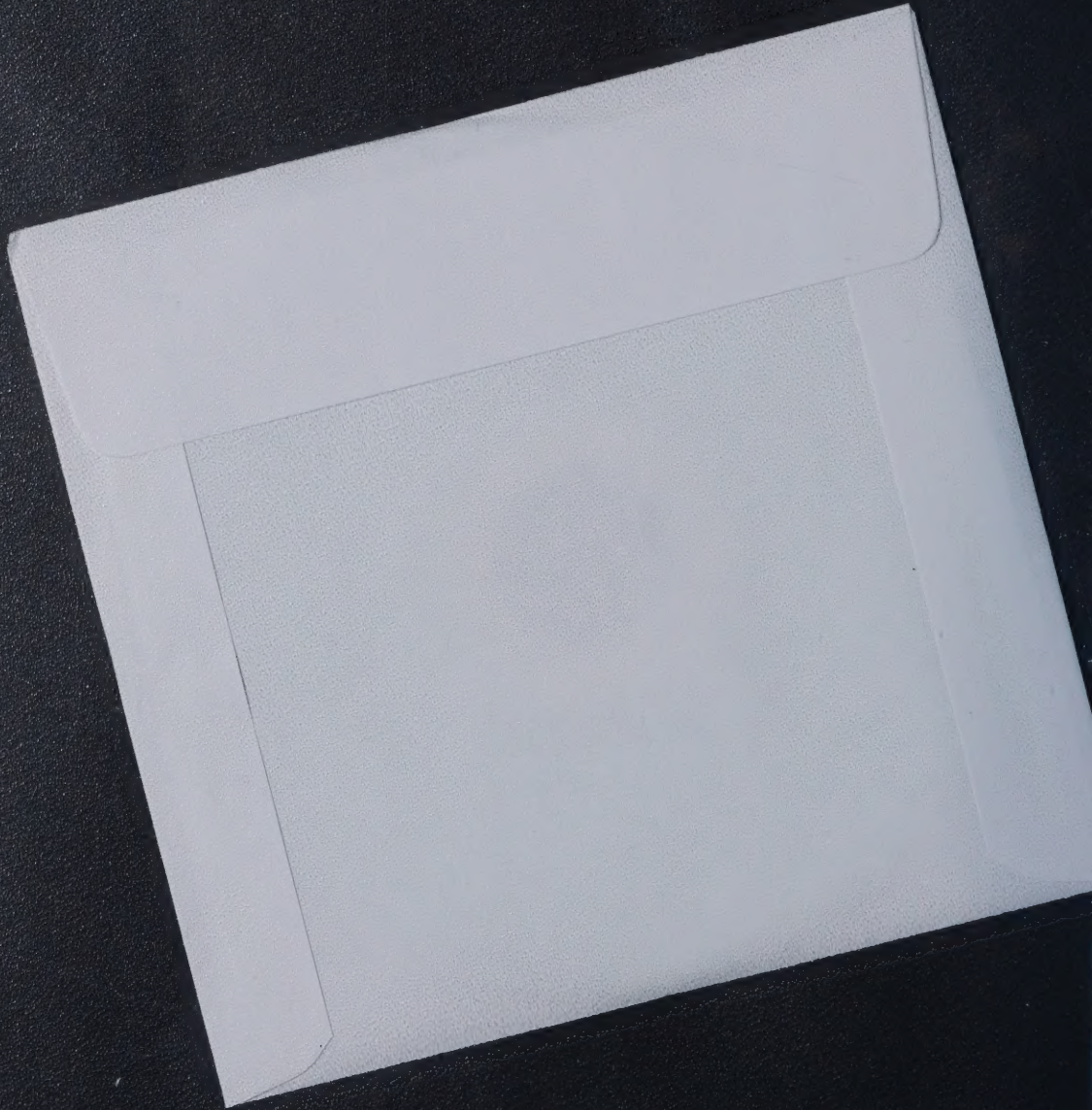
STATISTICAL ANALYSES REPORTS

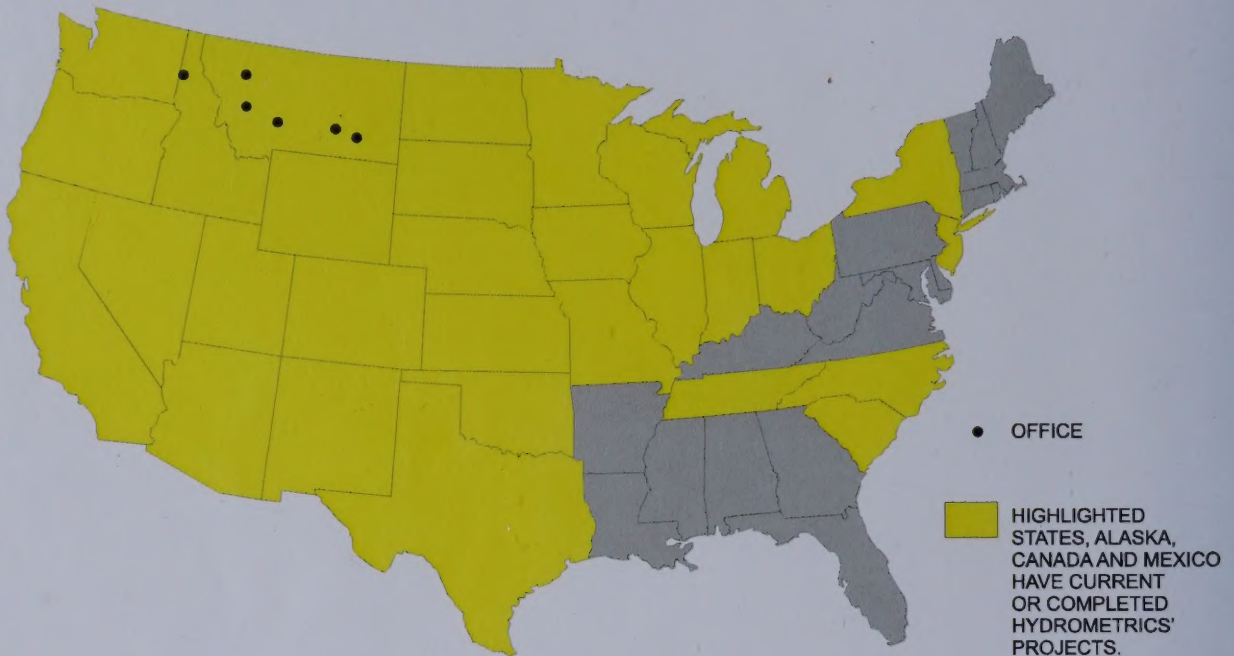
Data Validation and Statistical
Evaluation of December 2016
Groundwater Quality Data

City of Helena Landfill
Appendix B - Statistical Analysis Reports

March 2017


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